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US 3846572 A

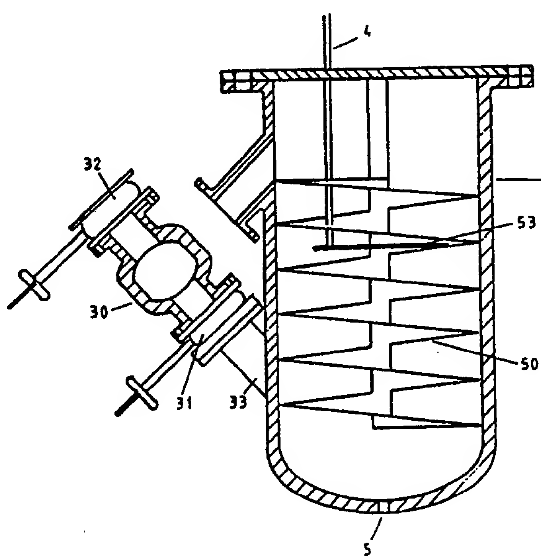
(58) Field of search
UK CL (Edition J) A2B BKR BKW BMS1 BMS5 BMV1 BMV5 BW
INT CL[4] A23L

(54) Oil-reduced snack foods

(57) In a process for reducing the oil cointent of oil rich snack foods such as potato-based and cereal based ready-to-eat products which consist of thin slices, flakes or other shapes and are optionally flavoured, the oil is "washed out" of the snack food in an extraction vessel using a solvent as a liquefied gas in the liquid phase, the resulting oil-rich solvent is passed through a heat exchanger, the separated oil is collected (distilled out) and the gaseous distillate is recondensed into liquefied gas in the heat exchanger and recycled to the extraction vessel.

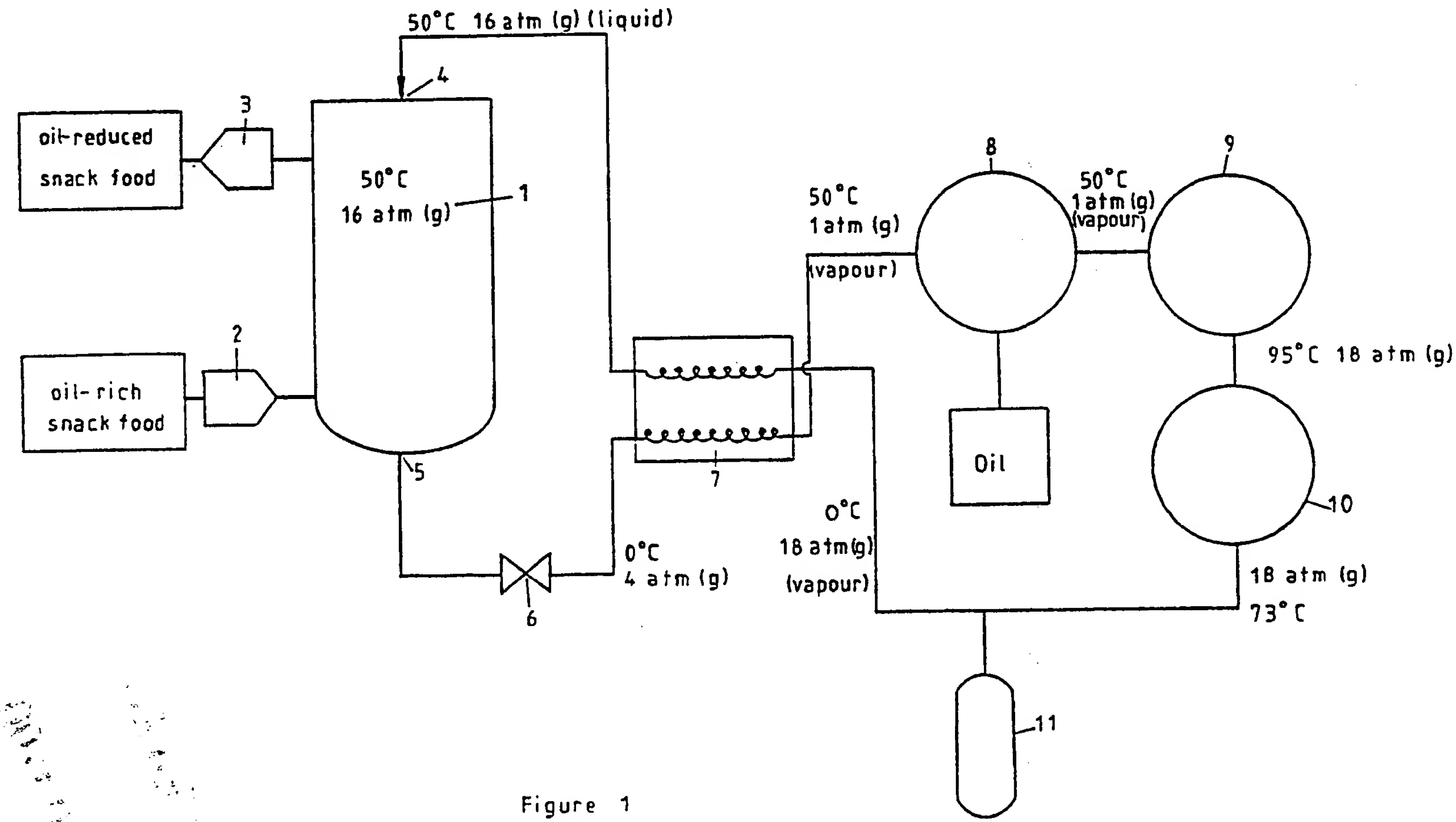
Apparatus described includes an extraction vessel 1 having snack food inlet part 33 as shown, and above part 33 an outlet part (43), sparge ring 53 for supplying liquified gas and perforated shelf 50 capable of reciprocating linear and/or rotary vibration.

Figure 3



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 225 205 A



50°C 16 atm (g) (liquid)
4
3
oil-reduced snack food
50°C
16 atm (g)
1
2
oil-rich snack food
5
6
0°C
4 atm (g)
7
50°C
1 atm (g)
(vapour)
8
50°C
1 atm (g)
(vapour)
9
95°C 18 atm (g)
Oil
0°C
18 atm (g)
(vapour)
10
18 atm (g)
73°C
11

Figure 1

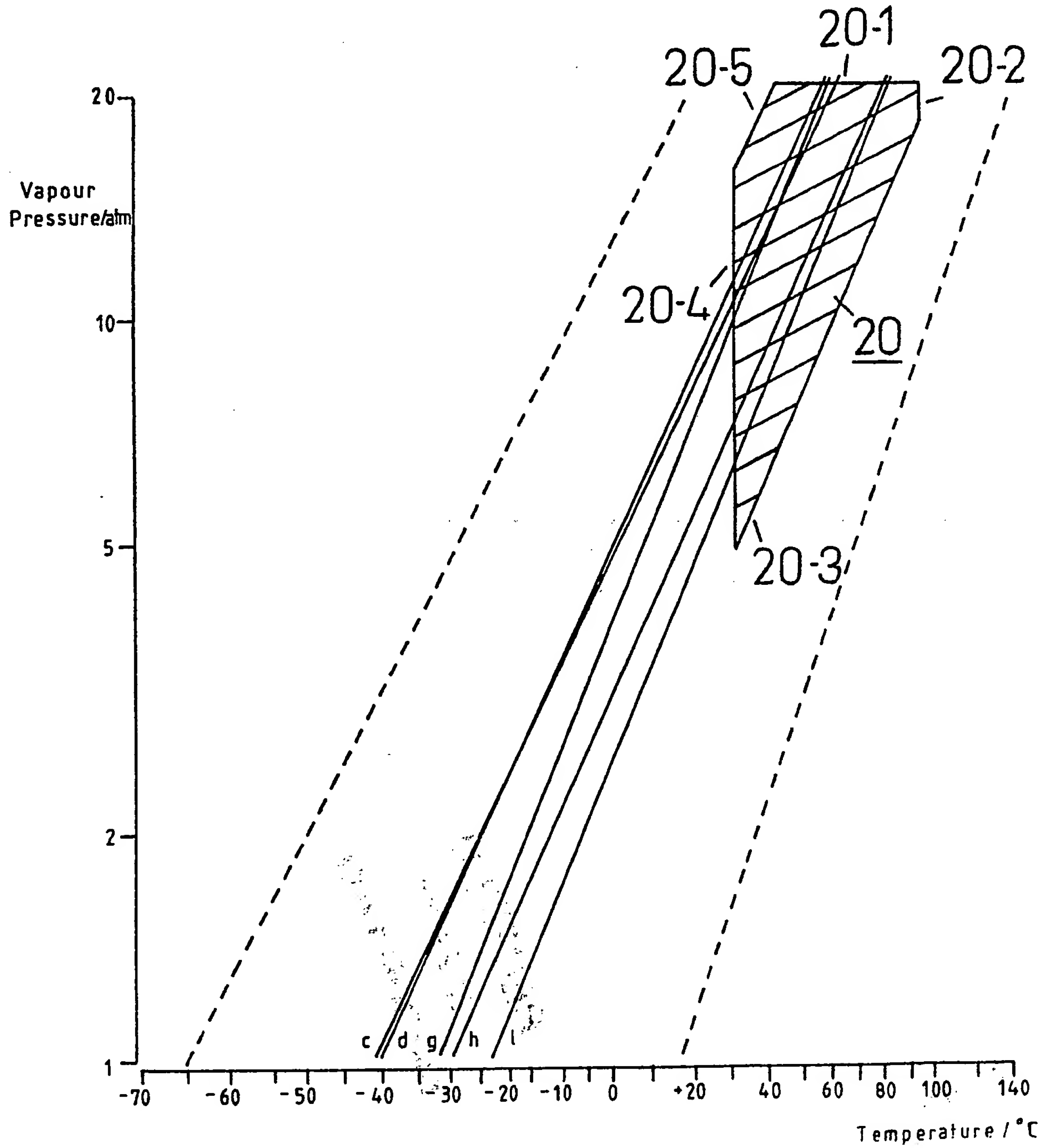

20-1
20-5
20-2
20
Vapour
Pressure/atm
20-4
10
20
5
2
1
20-3
c
d
g
h
l
-70
-60
-50
-40
-30
-20
-10
0
+20
40
60
80
100
140
Temperature / °C

Figure 2

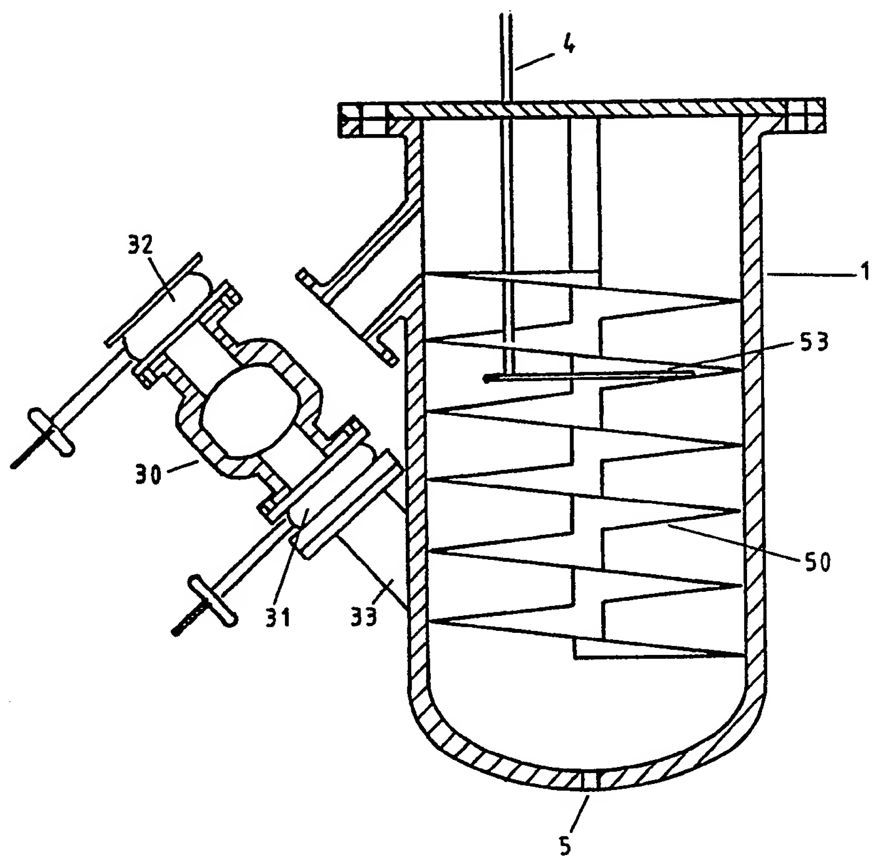


Figure 3

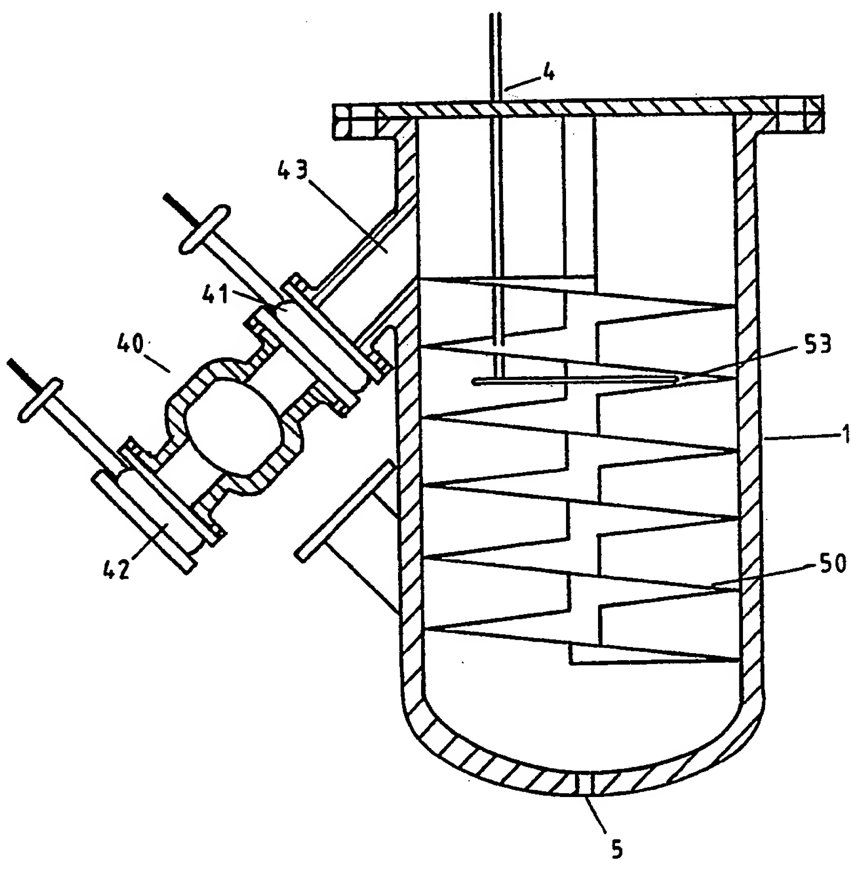


Figure 4

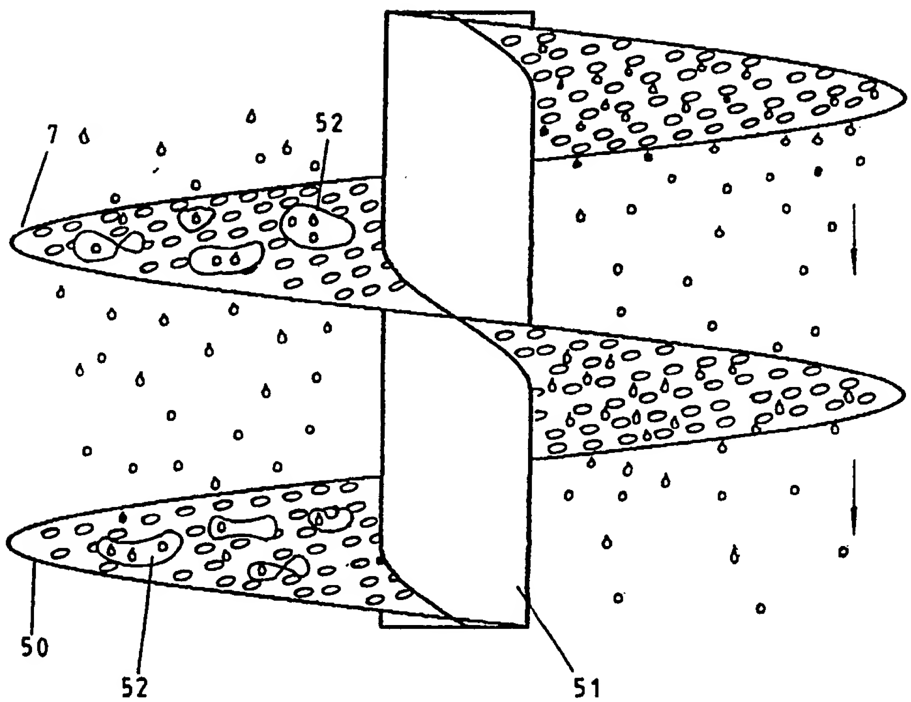


Figure 5

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TITLE: OIL-REDUCED SNACK FOODS

FIELD OF THE INVENTION

The invention relates to the removal of oil from oil-rich snack foods such as potato crisps and corn products; and provides a process and apparatus for such oil removal.

BACKGROUND OF THE INVENTION

In this Specification the term 'oil-rich snack foods' is used to define a range of cooked potato-based and cereal-based products all of which are of the ready-to-eat type and consist of thin slices, flakes or other shapes which are optionally flavoured. Potato crisps (known in the USA as potato chips) are a typical example of such a product. The term is not used to include nuts, which have a high natural oil content but which are very dense and therefore not susceptible to treatment in the same way as the less dense potato and cereal-based products. Conventional potato crisps have an oil content of about 38% by weight. This causes concern in a number of respects. The oil represents a very significant element in the total cost of the product, so that a high oil content increases the manufacturing cost and the price. The oil is liable to oxidation in the light and in the air, and packaging costs are therefore increased to provide a packaged product that has an acceptable shelf life. Currently preferred packaging includes the use of metallized film which is both light- and vapour-impervious, but that is a relatively expensive packaging material. Finally the public's awareness of the benefits of a low fat diet means that a substantially reduced oil content of such snack foods is highly desirable from both a public health and a marketing point of view.

As a result of the search for a method of reducing the oil content of oil-rich snack foods, there are now commercially

available potato crisps which are advertized as being oil-reduced, but which still contain about 25% by weight of oil.

It is an object of this invention to provide a process and apparatus that is capable of reducing the oil content of potato crisps, for example, to about 1% by weight without impairing the flavour or texture of the product.

SUMMARY OF THE INVENTION

The invention provides a process for reducing the oil content of oil-rich snack foods (as herein defined) which comprises

contacting the oil-rich snack food in an extraction vessel with liquefied gas at an oil extraction temperature and a superatmospheric pressure sufficient to maintain the gas in the liquid phase;

removing the oil-rich liquefied gas from the extraction vessel and passing it through an expansion device to decrease its temperature and pressure and achieve partial vapourization of the gas;

passing the resulting mixture of gas and oil-rich liquefied gas through a heat exchanger to a distillation zone where all of the gas is distilled off and the extracted oil is collected;

compressing the distillate gas and removing some of the heat generated in a cooler;

condensing the compressed distillate vapour in the heat exchanger by cooling it to a temperature slightly above the oil extraction temperature; and

recycling the liquefied gas to the extraction vessel.

Tests have shown that the oil content of conventional potato crisps treated by the above process can be reduced from about 38% by weight to about 1% by weight, without any

deterioration in the taste or texture of the product. Similar impressive results are obtained with a range of corn-based oil-rich snack foods.

Any artificial or surface flavours or seasonings added to the snack foods before treatment would of course be washed out together with the oil, so it is important that the step of spraying with a seasoning or flavour composition is carried out after the oil reduction process of the invention.

The use of liquefied gases as solvents in food production has previously been known solely in the fields of flavour extraction and decaffeination. The pressures at which the gases have been used have been relatively high. Carbon dioxide at above 100 atmospheres gauge (102.3 bar) is for example a typical solvent, although for flavour extraction other organic liquefiable gases have also been proposed.

One major advantage of using a liquefiable gas in the process of the invention is that , because the vapour pressure of residual solvent in the food product at ambient temperatures exceeds 1 atmosphere (1.0 bar), when the food product is removed from the extraction vessel any residual solvent evaporates rapidly and completely.

The temperature at which the oil extraction step is carried out may, in principle, vary from the normal boiling point to the critical temperature of the liquefied gas. However the preferred pressure is within the range of from 0 to 20 atmospheres gauge (1.0 to 21.3 bar). This pressure range defines a precise temperature range for each particular liquefiable gas, which corresponds approximately to the temperature range from the normal boiling point to 1.4 times the normal boiling point of the liquefiable gas used as solvent, as expressed in degrees Kelvin. Further

criteria governing the temperature of the oil extraction step are, however, the need for commercially acceptable extraction times and the need to avoid food degradation. Too low an extraction temperature results in extraction times that are unacceptably slow, and too high an extraction temperature may cause food degradation, involving loss of taste, texture and/or colour.

The operating pressure is dictated to an extent by the choice of liquefiable gas used as solvent, and in particular by the vapour pressure of that gas as identified by its normal boiling point. Use of a gas with too low a normal boiling point means that the process pressure has to be increased or the process temperature decreased in order to maintain the gas in its liquid state. Use of a gas with too high a normal boiling point increases the time for the gas to evaporate from the snack food after treatment.

Preferred operating parameters are set out graphically in, and explained with reference to, Figure 2 below.

Subject to the above restraints on its normal boiling point, the liquefiable gas that is used as the solvent in the process of the invention may be an alkane, chloroalkane, fluoroalkane, chlorofluoroalkane, or ether. Examples of suitable gases, and the main criterion of normal boiling point affecting their suitability are set out in Table 1 below.

TABLE 1

	Compound	NBP in °C
a difluoromethane	CH_2F_2	-52 *
b 1,1,1-trifluoroethane	$CH_3.CF_3$	-47 *
c propane	C_3H_8	-42 *
d monochlorodifluoromethane	$CHClF_2$	-41 *
e monochloroperfluoroethane	$CClF_2.CF_3$	-39 *
f perfluoropropane	C_3F_8	-36 *
g monofluoroethane	C_2H_5F	-32 *
h dichlorodifluoromethane	CCl_2F_2	-30 *
i 1,2,2,2-tetrafluoroethane	$CH_2F.CF_3$	-26 *
j 1,1-difluoroethane	$CH_3.CHF_2$	-25 *
k chloromethane	CH_3Cl	-24 *
l dimethyl ether	CH_3OCH_3	-23 *
m isobutane	$CH(CH_3)_3$	-12
n 1-chloro-2,2-difluoroethane	$CH_3C.ClF_2$	-10
o monochloromonofluoromethane	CH_2ClF	-9
p n-butane	C_4H_{10}	-1
q 2,2-difluoropropane	$CH_3.CF_2.CH_3$	0
r 1,1,1,3-tetrafluoropropane	$CH_2FCH_2.CF_3$	1
s 1-fluoropropane	$CH_3.CH_2.CH_2F$	2
t perfluorobutane	C_4F_{10}	4
u 1,1-dichloroperfluoroethane	$CCl_2F.CF_3$	4
v dichloromonofluoromethane	$CHCl_2F$	9
w methyl ethyl ether	$CH_3OC_2H_5$	11
x monochloroethane	$CH_3.CH_2Cl$	12

* preferred vapour pressure range of -50°C NBP -20°C.

Drawings

Figure 1 is a flow chart illustrating a process according to the invention;

Figure 2 is a vapour pressure-temperature diagram

illustrating preferred parameters for selection of a liquefied gas for a process according to the invention;

Figures 3 and 4 are axial sections through an extraction vessel for use in a process according to the invention, taken along different vertical planes; and

Figure 5 is a detail, in side elevation, of the helical shelf which is provided in the interior of the extraction vessel of Figures 3 and 4.

Referring first to Figure 1, oil-rich snack food is charged into an extraction vessel 1 in a batchwise manner through an air lock 2 and discharged from the extraction vessel 1 in similar manner through an air lock 3. A preferred construction of the extraction vessel 1 is described in detail below with reference to Figures 3 and 4.

Oil is extracted from the snack food in the vessel 1 by means of a countercurrent flow of a solvent which is a liquefied gas chosen from the criteria discussed in detail below with reference to Figure 2. The liquefied gas is introduced into the vessel 1 at a charge port 4 and discharged from a miscella port 5.

Typical temperatures and pressures are shown throughout Figure 1 to illustrate not absolute values but a typical cycle of pressure and temperature variations around the circuit using propane gas as the solvent. Thus in Figure 1 the temperature of the liquefied propane gas solvent in the vessel 1 is shown as $50^{o}C$ and the pressure 16 atmospheres gauge (17.2 bar). From the miscella port 5 the oil-rich liquefied propane is vented through an expansion valve 6 to reduce its pressure to about 4 atmospheres gauge (5.1 bar). Some evaporation takes place and there is isenthalpic cooling to about $0^{o}C$. The oil-rich liquid propane is then passed through a heat exchanger 7 from which it emerges at a temperature of about $50^{o}C$ and a pressure of about 1 atmosphere gauge (2.0 bar).

At this temperature and pressure the propane, originally in its liquid phase, has passed completely to its gaseous phase leaving only the dissolved oil from the snack food in the liquid phase for isolation and collection in a distillation and separation vessel 8. The oil so collected is sufficiently pure for re-use.

From the vessel 8 the propane gas at 50°C and 1 atmosphere gauge (2.0 bar) is compressed in a compressor 9 to about 18 atmospheres gauge (19.3 bar). The outlet temperature is a function of compressor design, including the number of compression stages and the degree of intercooling. In Figure 1 a typical outlet temperature of 95°C is shown.

From the compressor 9 the propane gas is passed to a cooler 10. The cooling achieved in the cooler 10 is adjustable. At full cooling the cooler 10 is sufficient to liquefy the propane for storage at 11. Full cooling is therefore used immediately prior to shut-down. Under normal operating conditions however a lesser extent of cooling is appropriate, and partially cooled propane gas is passed from the cooler 10 to the heat exchanger 7 where it is further cooled and condensed at 50°C. From the heat exchanger 7 the liquid propane is recycled to the extraction vessel 1. A pressure drop of 2 atmospheres (2.0 bar) is shown across the heat exchanger 7.
The degree of cooling effected in the cooler 10 should be sufficient to maintain a heat balance in the heat exchanger 7 so that the heat required to raise the temperature of the propane vapour passing through the heat exchanger 7 from the valve 6 to the chamber 8, and to compensate for the pressure drop of that propane vapour, is matched by that provided by the partly cooled vapour passing from the cooler.

The above cycle is most energy-efficient. The only steps requiring significant energy input are the compression and cooling steps, and generally adiabatic conditions are used elsewhere around the circuit.

Clearly other temperatures and pressures would be suitable for other solvents. Figure 2 shows vapour pressure vs temperature relationships for five different liquefiable gases, identified with the identification letters given in Table 1. Also shown in Figure 2 are broken lines indicating the limits of the most volatile and least volatile gases to be used in the process of the invention, corresponding to liquefaction at 20 atmospheres gauge (21.3 bar) and 0 atmosphere gauge (1.0 bar) respectively at about $15^{\circ}C$.

More significantly, Figure 2 shows a hatched area 20 representing the preferred operating conditions of the extraction step of the process of the invention. The boundaries of this area are defined as follows:

Boundary 20-1 indicates not too high a pressure in the extraction vessel. Too high a pressure is not energy-efficient and requires a strong pressure-resistant vessel. Preferably the pressure is less than 20 atmospheres gauge (21.3 bar).

Boundary 20-2 indicates not too high a temperature in the extraction vessel, lest the snack food is damaged in taste or colour or texture. Clearly this upper limit will depend on the food, but an upper temperature limit of $90^{\circ}C$ is sufficient for most foodstuffs.

Boundary 20-3 is a preferred lower limit to the volatility of the gas used as solvent, and indicates a gas with a normal boiling point of $-20^{o}C$.

Boundary 20-4 indicates not too low a temperature in the extraction vessel. This is a practical requirement, as at low temperatures the time taken for oil extraction from the snack food increases. A lower temperature limit of $30^{o}C$ is shown.

Boundary 20-5 is a preferred upper limit to the volatility of the gas used as solvent. Preferably the gas chosen will be one with a normal boiling point of above $-50^{o}C$.

Figures 3 and 4 illustrate the novel construction of a preferred extraction vessel 1. The section plane of Figure 3 is through an inlet chamber 30 which is a pressure vessel isolated from the interior of the extraction vessel 1 by a gate valve 31 and from ambient pressure by a gate valve 32.

An inlet port 33 loads from the inlet chamber 30 to the interior of the extraction chamber 1. An evacuation and pressurization port (not shown) enables the pressure in the inlet chamber 30 to be reduced to that in the extraction vessel 1 or increased to atmospheric before opening the respective gate valves 31 and 32. The section plane of Figure 4 is through a discharge chamber 40 which is of similar construction to the inlet chamber 30 and in which the relevant reference numerals have been increased by 10.

The inlet and discharge chambers 30 and 40 and the associated gate valves thus form air locks for the movement of batches of snack food into and out of the extraction chamber 1.

Between the inlet port 31 and the discharge port 41 is a helically formed perforated shelf 50 which is shown in greater detail in Figure 5. The shelf 50 is mounted on a central pillar 51 which is connected to means (not shown) for imparting to the shelf a reciprocatory linear and/or rotary vibration which in practice is sufficient to impel discrete items 52 of snack food on the shelf up the shallow inclined angle of the shelf from the inlet port 33 to the discharge port 43.

A countercurrent of liquefied gas passes down the extraction chamber 1 from a sparge ring 53 supplied by the liquefied gas charge port 4 (see Figure 1), to the miscella port 5.

CLAIMS

1. A process for reducing the oil content of oil-rich snack foods (as herein defined) which comprises

contacting the oil-rich snack food in an extraction vessel with liquefied gas at an oil extraction temperature and a superatmospheric pressure sufficient to maintain the gas in the liquid phase;

removing the oil-rich liquefied gas from the extraction vessel and passing it through an expansion device to decrease its temperature and pressure and achieve partial vapourization of the gas;

passing the resulting mixture of gas and oil-rich liquefied gas through a heat exchanger to a distillation zone where all of the gas is distilled off and the extracted oil is collected;

compressing the distillate gas and removing some of the heat generated in a cooler;

condensing the compressed distillate vapour in the heat exchanger by cooling it to a temperature slightly above the oil extraction temperature; and

recycling the liquefied gas to the extraction vessel.

2. A process according to claim 1, wherein the superatmospheric pressure in the extraction vessel is from 0 to 20 atmospheres gauge (1.0 to 21.3 bar).

3. A process according to claim 2, wherein the oil extraction temperature is from 30°C to 90°C.

4. A process according to any preceding claim, wherein the liquefied gas is one which has a normal boiling point of from -65°C to +15°C.

5. A process according to claim 4, wherein the liquefied gas is one which has a normal boiling point of from $-50^{o}C$ to $-20^{o}C$.

6. A process according to any preceding claim, wherein the liquefied gas is an alkane, a chloroalkane, a fluoroalkane, a chlorofluoroalkane, an ether or a mixture thereof.

7. A process according to any preceding claim, wherein the oil-rich snack food is contacted with the liquefied gas in the extraction vessel in countercurrent flow.

8. A process according to claim 7, wherein the oil-rich snack food is moved through the extraction vessel on a vibrating conveyor.

9. A process according to claim 8, wherein the vibrating conveyor comprises a helically formed perforated shelf mounted on a vibrating pillar, the vibration being sufficient to induce movement of the snack food up the helically formed shelf from the bottom of the helix to the top.

10. A process according to claim 9, wherein the introduction of the snack food into the extraction vessel and the removal of the snack food from the extraction vessel is in batches via inlet and discharge chambers which are provided with valves for maintaining the superatmospheric pressure in the extraction vessel.

11. An extraction vessel for use in a process according to claim 9, comprising a pressure vessel, a helically formed perforated shelf in the pressure vessel mounted on a vertical pillar, means for imparting vibratory movement to

the pillar and hence to the shelf to cause particulate material placed on a bottom end of the shelf to move upwardly to a top end thereof, an inlet for depositing particulate material on the bottom end of the shelf, an outlet for receiving particulate material from the top end of the shelf, and means for introducing a liquefied gas into an upper portion of the pressure vessel and removing it from a lower portion.

12. A vessel according to claim 11, wherein the inlet comprises an air lock chamber for the batchwise introduction of particulate material into the pressure vessel onto the bottom end of the shelf without loss of pressure from the chamber.

13. A vessel according to claim 12, wherein the outlet comprises an air lock chamber for the batchwise removal of particulate material from the pressure vessel from the top end of the shelf without loss of pressure from the chamber.

14. A process for reducing the oil content of oil-rich snack foods, substantially as described herein with reference to the drawings.

15. An extraction vessel for use in a process for reducing the oil content of oil-rich snack foods, substantially as described herein with reference to Figures 3 to 5 of the drawings.

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